Korea Update

Hydrogen and Fuel Cells Activities in Korea

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Ministry of Knowledge and Economy

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-. Energy Situations in Korea

Population: ~50 million

Energy Import (97%)

5th Largest Oil importer

2nd Largest LNG importer

10th Energy consumption

-. Hydrogen and Fuel Cell Program since 1988

Background: Urgent Energy and Environmental Challenges

Programs: Research,

Development,

Validation,

Demonstration,

Commercialization

Defined NRE Resources

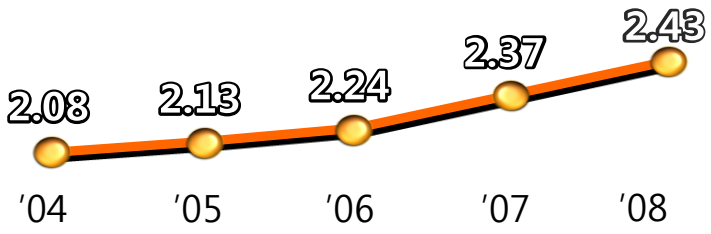
Renewable Energy : Transform natural resources such as sunlight, water and biomass into usable energy sources

8 sources : PV, Solar Thermal, Wind, Waste, Bio(LFG, Bio-Fuels), Hydro, Geothermal, Marine

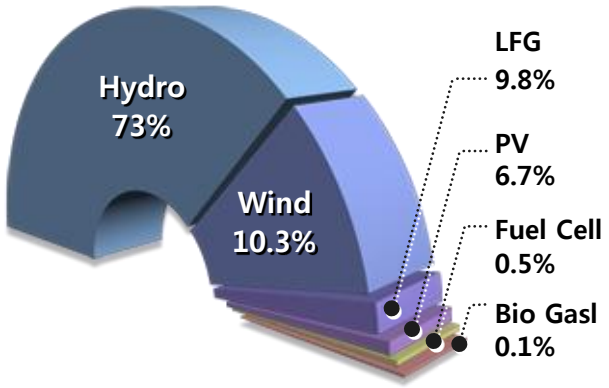
New Energy : conventional fossil fuels processed and used as cleaner energy sources

3 sources : Fuel cell, Hydrogen, Coal Liquefaction or Gasification

NRE Share (%)



Power Generation from NRE (2008)



Policy Schemes for NRE

Deployment Program

General Subsidy	(1994~), Factories, Individual Buildings, Schools, etc Government 50%+ Individuals 50% Budget : 14 bil won(11.6mil USD), 2010
Local deployment	(1996~), Public buildings, Social welfare facilities, etc Government 50%+ Local 50% Budget : 70 bil won(58.3mil USD), 2010
1 Million Green Homes	(2009~), Residential house, Apartment house, etc Government 50%+ Individuals 50% Budget : 96.2 bil won(80mil USD), 2010

International Cooperation

- Intergovernmental Meetings, Initiatives, Partnerships,
- Bilateral Cooperative Activities (Spain, Germany etc)
- IPHE (International Partnership for Hydrogen and Fuel cells in the Economy)
- IEA/REWP (Renewable Energy Working Group)
- APEC/EGNRET (Expert Group on NRE technology)
- IRENA (International Renewable Energy Agency)
- APP/REDGTF (Renewable Energy & Distributed Generation Task Force)

Certificates System

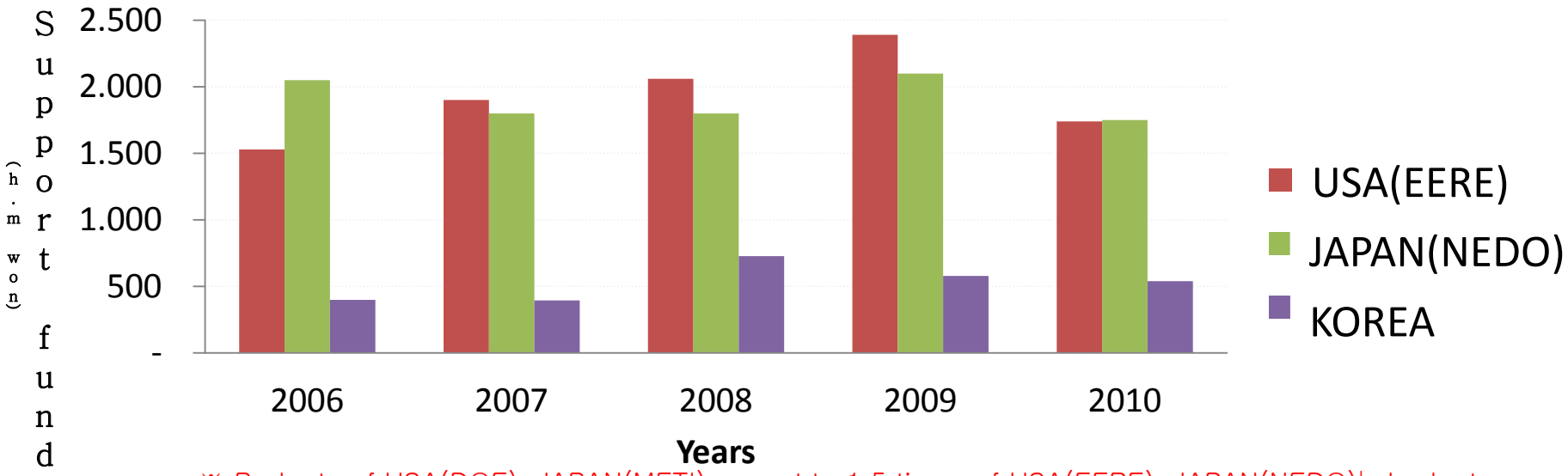
- Renewable Energy Certificate Scheme
  - 546 models in 25 items

Roles and Activities of Government

Public R&D investment (unit: Million USD)

R&D area	2006	2007	2008	2009
Energy Efficiency	69.2	79.0	103.5	143.0
CCS	10.2	15.2	19.5	20.0
Resources Technology	13.1	13.7	16.4	16.6
New and Renewable Energy	115.8	120.9	195.3	205.6
Power Generation and Electricity Delivery	144.6	163.3	123.4	114.5
Nuclear Power	-	-	50.8	61.0
Radioactive Waste Management	-	-	-	4.4
Energy & Resources Recycling	-	4.5	7.2	11.5
Sum	352.9	396.6	516.1	576.6

Hydrogen fuel cell R&D budget



※ Budgets of USA(DOE), JAPAN(METI) are set to 1.5 times of USA(EERE), JAPAN(NEDO)'s budgets

Nation	R&D Budget / year	Distribution business / year
USA (DOE)	2,240 hundred million Won[1)]	420 hundred million Won
JAPAN (2010)	1,070 hundred million Won[2)]	680 hundred million Won[3)] accumulate 100hundred prediction (standard 2011)
KOREA	320 hundred million Won	115 hundred million Won

1) DOE EERE Hydrogen Fuel cell program + SECA program(500 hundred million Won / year)
2) NEDO Hydrogen Fuel cell R&D business
3) Supporting subsidy for Residential Fuel Cell System Construction

1 hundred million won = 87,000 dollars

Strategic Choice of 9 Potential Sectors

based on Marketability, Technical Ability, Urgency

	9 Sectors	World Market Size	Domestic Production	Technology Level (Advanced Nations=100)
Rapid Development of World Market Development of related Domestic Industries Early Growth Engine	Photovoltaic	20.0 bil. $	140 mil. $	83%
	Wind	37.5 bil. $	400 mil. $	79%
	LED	14.0 bil. $	1,160 mil $	65%
	Electrical IT	13.0 bil. $	70 mil. $	85%
Huge Potential World Market Urgent Need for Technological Advance Next-Generation Growth Engine	Hydrogen Fuel Cell	3.2 bil. $	–	66%
	IGCC (Integrated Gasification Combined Cycle)	8.6 bil. $	–	56%
	CTL / GTL (Coal-to-Liquids/Gas-to-Liquids)	28.5 bil. $	–	50%
	Energy Storage	0.5 bil. $	–	60%
	CCS (CO2 Capture & Storage)	–	–	65%

Vision of Hydrogen Economy (MKE, 2003, revised 2008)

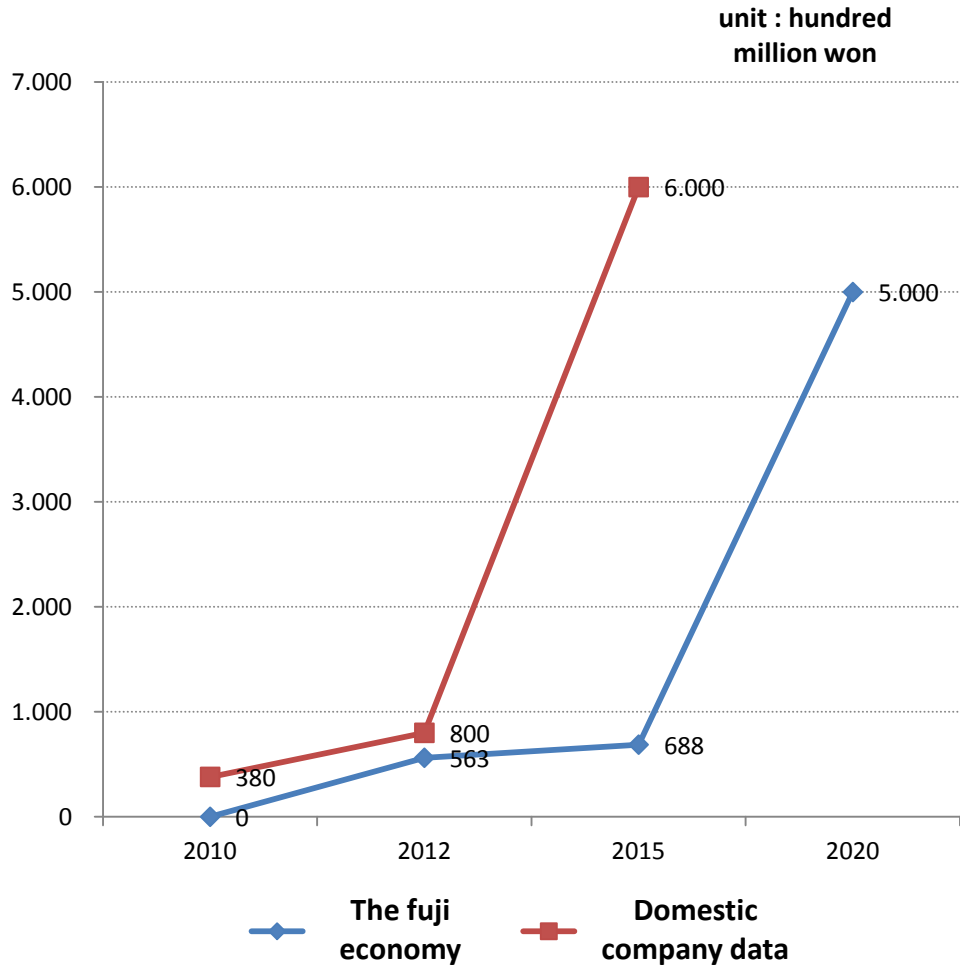
2003 ~ 2012	2013 ~ 2020	2021 ~ 2030	2031 ~ 2040
R&D and Demonstration	Market Formation	Market Expansion	Initial Phase of Hydrogen Economy
. Demonstration and Supply under Government Support . Hydrogen Energy Market Share ▶ 0.03%	. Accomplishment of Technical Development	. Expansion of Hydrogen Infra.	. Self-Growing Market

'03-'05	'06-'08	'09-'12
R&D ▶	Demo ▶	Market Intrusion
● Decentralized (250-1000kW)		400 MW
● Industrial (10-50kW)		80 units
● Residential (under 3kW)		10,000 units
● Hydrogen Station		10 units
● Fuel Cell Vehicle		500 units
● Fuel Cell Bus		20 units

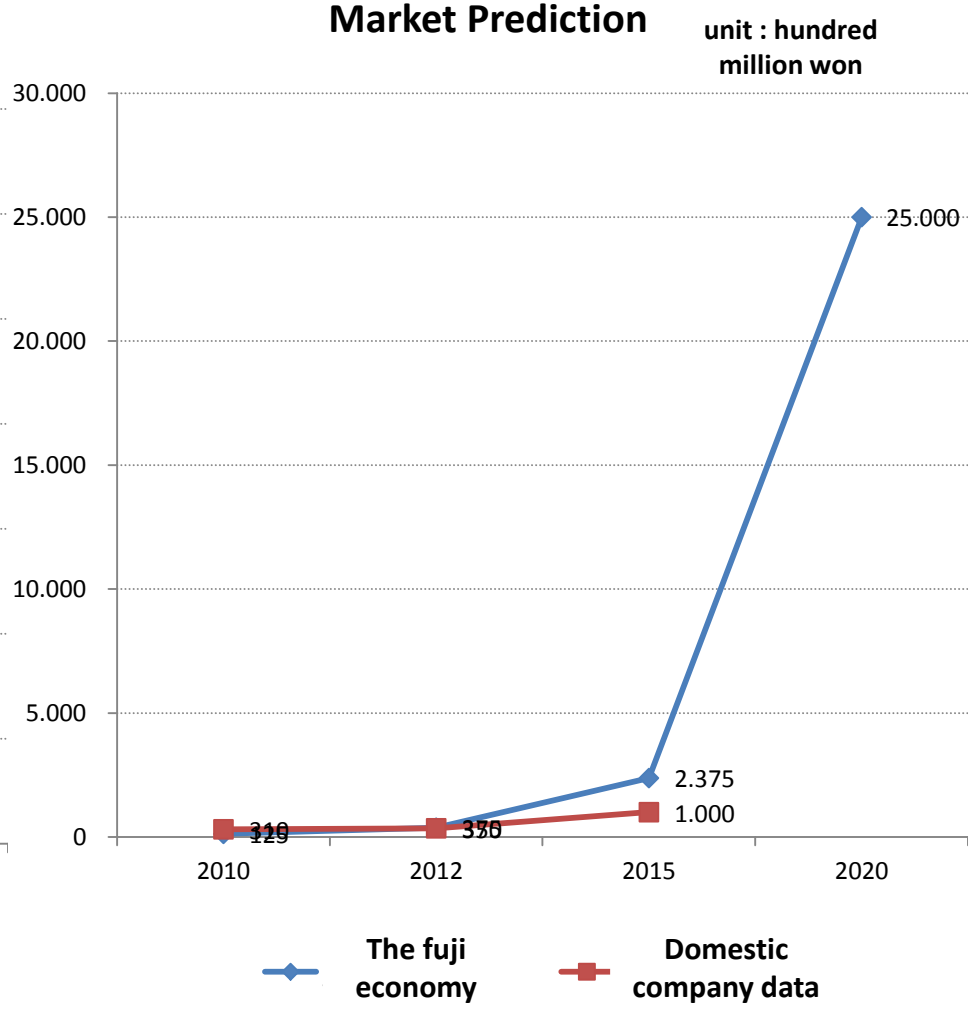
Fuel Cell System Market Share		
● Decentralized 1,000 MW ● Industrial 2,000 units ● Residential 100,000 units	10%	15%
Fuel Cell Vehicle Market Share		
● Hydrogen Station 500 units ● Fuel Cell Vehicle 50,000 units	15%	50%

Market outlook of domestic fuel cell

Korea Vehicle Fuel Cell Market Prediction



Korea Residential Fuel Cell Market Prediction



Fuel cell business and Market

Type	Field	Korean companies
PEFC	Consumer and Commercial (1kW~ 50kW) vehicle car/bus/truck (50kW~250kW) etc (military, submarine, airship, transportation, exclusive power supply...)	FUELCELLPOWER, GS FUELCELL, HYOSUNG, LG CHEM, SK, SAMSUNG ELECTRONICS, LG ELECTRONICS, LS cable & system, LSIS, KYUNG DONG NAVIEN, SAMCHULLY, HANWHA chemical corporation, DONGJIN SEMICEM, HANKOOK TIRE, HUYNDAI MOTOR COMPANY etc..
SOFC	Distributed power generation (250kW~several MW)	KEPCO POSCO SAMSUNG SDI
MCFC	Distributed power generation (250kW~seveal MW)	KEPCO POSCO POWER DOOSAN HEAVY INDUSTRIES & CONSTRUCTION

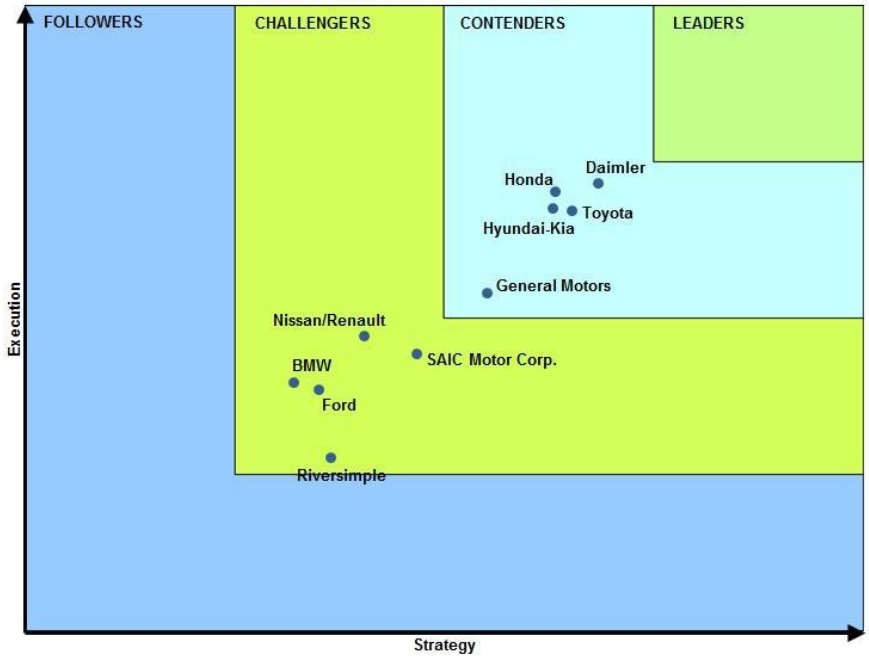
1 hundred million won = 87,000 dollars

Domestic FCV Fleet Program

	Domestic Fleet program (Phase I)	Domestic Fleet program (Phase II)
Period	Aug. 2006-July 2009	Dec. 2009-Nov. 2011
Vehicles	30 passenger cars 4 buses	80 passenger cars
Hydrogen fueling station	5 new stations (total: 10 stations)	Validate 700 bar H_2 stations (2) Upgrade 350 bar H_2 station
Operation	743,500 km (including Bus) Avg. fueling economy: 19.2 km/l	Resolve technical issues before starting small scale mass production
participation	Private companies	3 private companies, 1 province
Budget	$ 46.6 M (Government $23.3 M)	$17.6 M (Government $5.3 M)

CEV Specific Capability Ranking

- Daimler (69.9) > Honda (66.7) > Toyota (66.1) > HYUNDAI-KIA (65.1)
- Hyundai-KIA's fuel cell electric vehicle technology, Top ClassV



Daimler

- Ballard 's factories (Vancouver) 38% lease
- Early '12year,
  FC Stack manufacturing facility will be completed

Hyundai-Kia

- '11 EU FCEV was selected as demonstration business
- '12~'14year, 1000 demonstration

cars (Nordic target) will be produced

GM

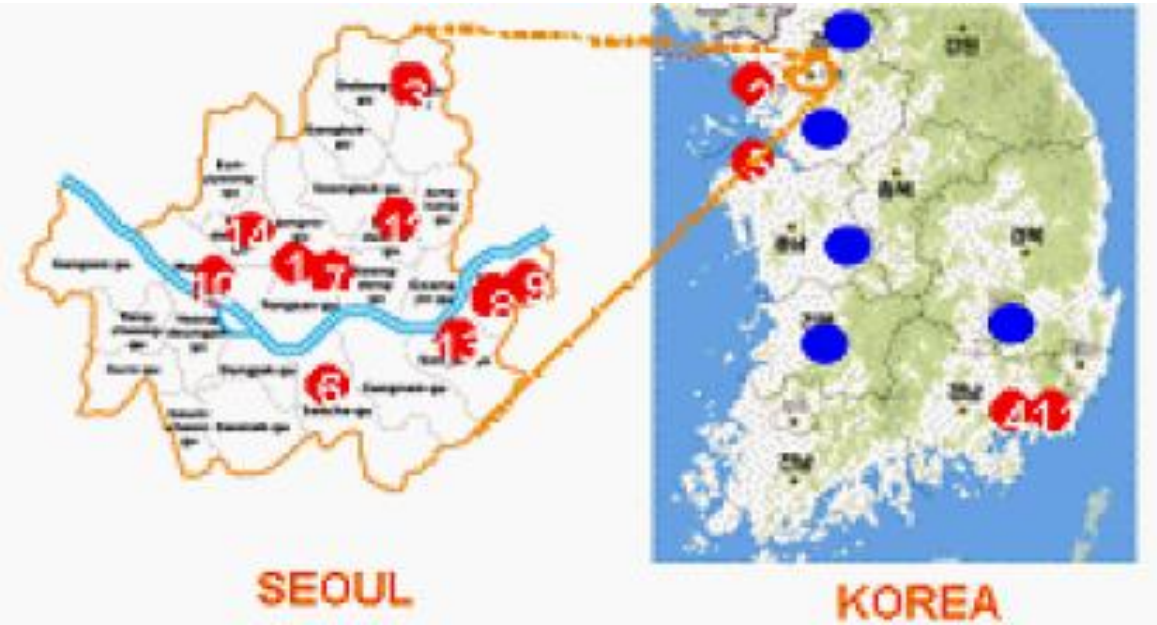
- 500 people committed to design and process development
- 150 people supported basic research (R & D Center)
- SAIC and the co-development,
  sharing of development platform

Nissan

- Development of commercial-level performance FC ('11)
- 1.6 times price reduction compared to '05year

40 units ('07) → 70 units ('08) → 100 units ('09)

- Development of PEMFC (GS) as well as SOFC (KEPCO) leading by companies
- Benchmarking of advanced techniques for enhancement of system efficiency and reliability
- Share of common technologies of stack, reformer, and BOP with PEMFC for vehicle
- Feasibility study of SOFC for auxiliary power unit (APU)



Domestic Fuel Cell Manufacturer Trends

퓨얼셀파워 FuelCellPower

''11.5 - Million Green Home Business # 1 market share.
Most domestic supply . (1,000 households accumulated)
'11.3 - LH corporation subjective “Co-housing residential fuel cell demonstration project 'a priority bidder bids”
'11.2 –Tree fuel cells export to Japan. (10kW class-1, 1kW class-2)
'10 - The smallest model release. (Installation area: 0.35m2)

GS 퓨얼셀

''11.1 - 1kW residential FC was postponed.
'10.10 - “20,000 hours ” cumulative power generation time
5kW buildings' FC planed in 2012
'10.3 - Participation in Million Green Home dissemination.
'10.3 -'GS Fuel Cell - Ocean City Gas - Samchully' signed the MOU for spread Green Home Business.
'10.1 -1kW integrated fuel cell system development.
'09.12 -5kW fuel cell system
- national project subjective business (2 years)

HYUNDAI HYSCO

‘12 .4 - New business - household (1kW PEMFC) fuel cell business
-metal separator stack is based on stainless steel

HYOSUNG

1kW Residential (low temperature) PEMFC fuel cell systems operation in progress.

Recent accomplishments

Hyundai-Kia Motor Co. - Seoul Metropolitan City (April 2011)

33 Fuel cell vehicles: 115㎾ (19 vehicles) + 100㎾ (14 vehicles)

Mileage: 23 km per 1ℓ of hydrogen

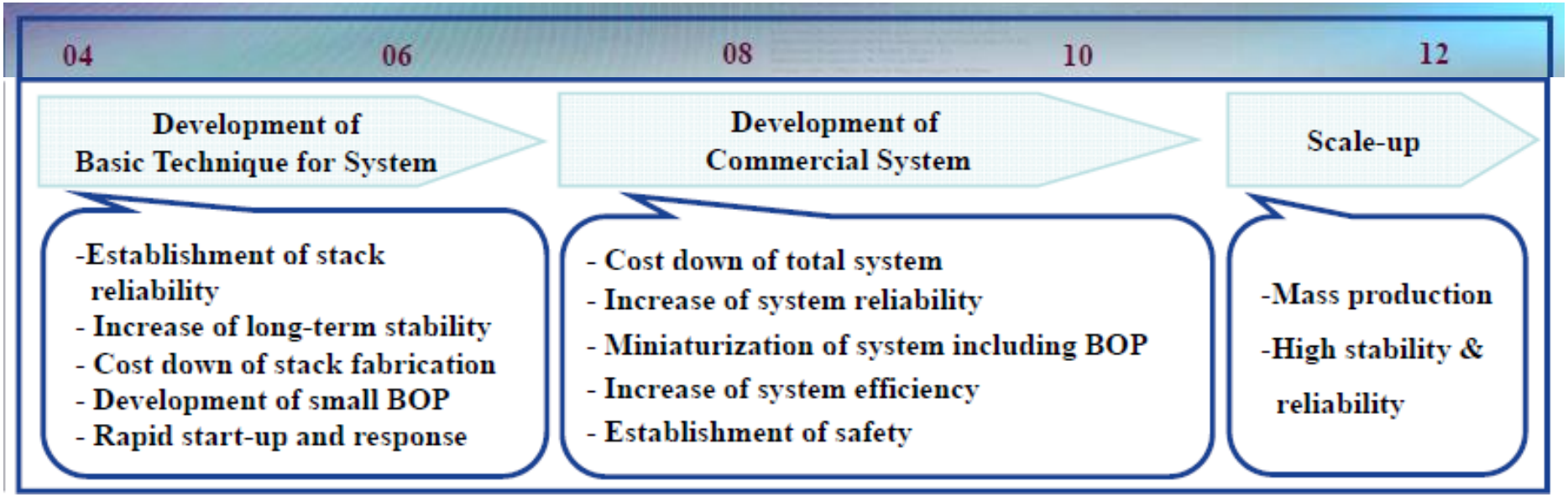
Max. speed: 160 km

Driving distance: 650 km

Hydrogen station in Seoul: 3 (completed) + 1 (being built)

PEMFC/SOFC for Residential Power Generation

Target	Efficiency > 40%, $15,000/kW



MCFC Development for Power Generation Application

93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10

2 kW Plant

25 kW Plant

100 kW Plant

250kW Plant

KEPRI-KEPCO

Dusan

300kW Plant

Commercial Proto Type

Posco

Dissemination

Basic Research
Fabrication Processing
Small Stack operation

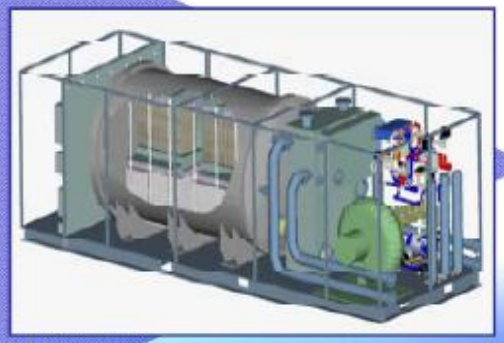
Established the Basic Technology

Enlargement
Increase cell No.
Internal manifolds
25 kW class stacl

Components Enlargement
25 kW stack test

-Enhancement cell and stack
- System Integration (BOP)
- Operation mode

Pilot Plant Test , Boreyong TP



Recent accomplishments

Korea Electric Power Co. + Posco Power + Samchully Gas Co.

($300 M dollars for 60MW power plant) in Kyunggi Province)

2012. 06 15MW Fuel cell power plant

2013. 06 45MW Fuel cell power plant

Posco Power – built **19** Fuel cell power plants (**32MW** in operation)

2.4MW Power plant in Seoul

Ministry of Education, Science & Technology (MEST)

21st Century Frontier R&D Programs: '03-'12

Hydrogen production	Biological, Photocatalytic, and Photochemical Production, Water Electrolysis
Hydrogen storage	Metal Hydrides, Chemical, Hydrides, nano-Structured materials, and etc.
Hydrogen Utilization and Policies	
Budget	$ 100M (Government:$86M, Industry:$14M)

Expected Grid Parity period

	국가	2008	2009	2010	2011	2012	2013	2014	2015
Photovoltaic Power Generation unit cost (Unit: $/kWh, Utility standards)	Korea	0.49	0.33	0.31	0.28	0.21	0.20	0.20	0.18
	Germany	0.50	0.30	0.25	0.22	0.20	0.18	0.17	0.16
	U.S.A.	0.36	0.30	0.25	0.21	0.17	0.17	0.16	0.15
	Japan	0.34	0.32	0.28	0.29	0.24	0.23	0.21	0.19
	China	0.36	0.20	0.18	0.16	0.12	0.12	0.12	0.11
Conventional Power Generation unit cost (Unit: $/kWh, Residential standards)	국가	2008	2009	2010	2011	2012	2013	2014	2015
	Korea	0.09	0.00	0.09	0.10	0.10	0.10	0.10	0.11
	Germany	0.25	0.26	0.24	0.26	0.27	0.28	0.28	0.29
	U.S.A.	0.22	0.23	0.24	0.24	0.25	0.25	0.26	0.26
	Japan	0.24	0.26	0.30	0.33	0.34	0.35	0.35	0.36
	China	0.08	0.08	0.08	0.09	0.09	0.09	0.10	0.10

*U.S.A.: california standards

	국가	2008	2009	2010	2011	2012	2013	2014	2015
PV Power Generation unit cost Existing power price (Unit: multiple)	Korea	5.4	4.1	3.4	2.8	2.1	2.0	2.0	1.6
	Germany	2.0	1.2	1.0	0.9	0.7	0.6	0.6	0.6
	U.S.A.	1.6	1.3	1.0	0.9	0.7	0.7	0.6	0.6
	Japan	1.4	1.2	0.9	0.9	0.7	0.7	0.6	0.5
	China	4.5	2.5	2.3	1.7	1.3	1.3	1.2	1.1

*Source : Photon 2011

Domestic fuel cell market forecast

section	2010			2012			2015			Note
	Sales	Employment (person)	The ratio of sales compared to government subsidy(%)	Sales	Employment (person)	The ratio of sales compared to government subsidy (%)	Sales	Employment (person)	The ratio of sales compared to government subsidy (%)	
Residential PEFC	310	120	53	350	150	49	1000	500	113	2012, 2015 including exports
Vehicle PEFC	380	530	38	800	750	64	6000	5771	374	Forming 120 parts of 2010's Related parts suppliers
S.P.G MCFC	1,215	200	192	1,900	360	258	8000	800	901	2015 including exports
Niche market DMFC	25	15	12	70	40	28	1700	300	567	Including exports
Total	1,930	865	79	3,120	1,300	106	16,700	7,371	454	

1) Cumulative sales and employment until 2010
2) Sales of 2012, 2015 : The year estimate (including export), Employment person is cumulative
3) vehicle sale performance
- 'Writing about the number of vehicle produced by based on production costs to sales of parts suppliers for vehicle production until 2010
- Prediction sales account pursuant to FCV mass-produce in 2012, 2015

Sales unit : hundred million won
1hundred million won = 87,000 dollars